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THE GEOLOGIC RELATIONS OF THE MARTINEZ GROUP OF CALIFORNIA AT THE TYPICAL LOCALITY.

THE term "Martinez Group" was first used by W. M. Gabb in his classification of the Cretaceous of California,[1] the group of strata provisionally so designated being considered by him as standing between the Chico of his Cretaceous A and his Tejon or Cretaceous B. The Martinez was said to be of small geographical extent and to bear such a relation to the Chico that future investigation might show it to be a part of that group. About sixty species were listed by Gabb from the group, most of them having been collected near the town of Martinez, in Contra Costa county.

For a number of years after the publication of the second volume of Gabb's work on the palæontology of California, the Martinez group was scarcely mentioned in geological literature, probably because, as described by him, it was not well understood. However as the Cretaceous B or Tejon came to be generally considered as Eocene the importance of the group, as a possible connecting link between the Chico-Cretaceous and the Tejon-Eocene, became evident.

[1] See Rep. Geol. Surv. of Cal. Palæontology, Vol. II, p. 13 of Preface. Gabb divided his Californian Cretaceous into a lower division, A, including the Shasta, Chico, and Martinez (?), and an upper division, B, or the Tejon. His Cretaceous B is now generally regarded as Eocene.

In a recent publication[1] by Mr. T. W. Stanton the fauna and stratigraphy of a number of the most important of Gabb's Martinez localities have been clearly discussed and a complete reorganization of the hitherto heterogeneous group effected. Mr. Stanton has shown the Martinez of Gabb to consist of two parts, one characteristic Cretaceous and inseparable from the Chico group, the other being more closely related faunally and stratigraphically to the Tejon-Eocene than to the Chico. The upper portion was therefore placed with the Tejon and designated as Lower Tejon. As a possible modification of his classification Mr. Stanton states that, "if more detailed field work makes it desirable to retain the name (Martinez) at all, it should be restricted to the Eocene (upper) portion . . . ."

In the following discussion the name Martinez is applied to that portion of Gabb's Martinez group which remains, after the removal of the Chico-Cretaceous element. The writer's statements are based on observations, extending over a period of several years, made in the typical region for the group, viz., that adjacent to the town of Martinez.

In the hills to the southwest of Martinez strata of unquestioned Chico age, containing a characteristic fauna, occur over a considerable area. In a fine outcrop of compact, bluish sandstone occurring on the west side of Alhambra Valley, and near the top of the Chico, the writer found an abundance of fossils, characteristic of this group, which are listed in the table below, under Locality No. 1. From this point to the east and west the structure of the strata is anticlinal, showing an apparently conformable series up as far as the Miocene on each side.

From the standpoint of stratigraphy, one would hardly be disposed to find fault with Gabb's conception of the Martinez, since in this, the typical locality, the Chico, Martinez, and Tejon, *appear* everywhere to be conformable, while numerous complications of the stratigraphy have still farther increased the difficulty of separating these three groups on stratigraphic grounds.

[1] The Faunal Relations of the Eocene and Upper Cretaceous on the Pacific Coast 17th Ann. Rep. U. S. Geol. Survey, 1895-6.

Lithologically there are some differences between the Martinez and the adjoining formations, the most important of which are the slightly different aspect of its sandstones and the frequent presence in them of considerable quantities of glauconite. The sandstones are often grayish, differing from the yellowish or bluish rocks of the Chico and the massive white to dull red Tejon sandstones. In many places the Martinez contains large quantities of glauconite disseminated evenly through the sandstones in rounded grains of considerable size. Glauconite does not seem to occur at all in the Chico but may possibly be found toward the base of the true Tejon. The truly glauconitic rocks belong principally to the Martinez.

While the group shows little which would serve to separate it stratigraphically or lithologically from the over and underlying formations, its fauna, on which Gabb based his classification, contains numerous elements throwing light on its geologic relations. Between the Chico-Cretaceous and the Miocene there are two distinct faunas present, viz., the Martinez (in part) and Tejon of Gabb, or the Lower and Upper Tejon of Mr. Stanton. As other criteria failed to separate satisfactorily the Chico, Martinez, and Tejon, extensive fossil collections were made by the writer at all possible points. A series of rich localities running across the strike from the Chico to the Tejon furnished the sequence of faunas as shown in the table on pages 770 and 771.

An examination of these lists shows that the lower Martinez beds, as stated by Mr. Stanton, have a fauna distinct from that of the Chico, and that, while the two sets of rocks may seem to be conformable, an unconformity, as yet unobserved, probably exists. There are no species common to localities 1 and 2 excepting *Dentalium Cooperi* which ranges up into the Tejon and appears to be identical with a form occurring in the lowest Miocene. Other localities furnishing a few imperfect fossils are known in beds perhaps somewhat lower down than Locality No. 2 but as yet no distinct overlapping of the two faunas has been discovered.

Locality No. 3, higher up in the group, furnishes a fauna of

TABLE SHOWING CHANGES OF FAUNA FROM CHICO TO TEJON.[1]

	Chico	Martinez	Tejon
LOCALITY NO. 1.—TYPICAL CHICO.			
1 *Corbula cultriformis* Gabb....	*		
2 *Meekia sella* Gabb.....	*		
3 *Meekia navis* Gabb	*		
4 *Meretrix arata* or *fragilis* Gabb	*		
5 *Mytilus quadratus* Gabb.....	*		
6 *Mytilus pauperculus* Gabb....	*		
7 *Nucula truncata* Gabb.....	*	*	*
8 *Pecten martinezensis* Gabb ...	*		
9 *Pectunculus Veatchi* Gabb....	*		
10 *Tellina Hoffmanniana* Gabb..	*		
11 *Tellina aequalis* Gabb (?)....	*		
12 *Venus varians* Gabb.....	*		
13 *Cinulia obliqua* Gabb.....	*		
14 *Cylindrites brevis* Gabb (?)...	*		
15 *Dentalium Cooperi* Gabb.....	*	*	*
16 *Gyrodes expansa* Gabb.....	*		
17 *Perissolax brevirostris* Gabb n. var.....	*		
18 *Pugnellus hamulus* Gabb	*		
19 *Solarium inornatum* Gabb ...	*		
20 *Helicoceras vermicularis* Gabb.	*		
21 Sharks' teeth 2 sp.....	*		
22 Teleost fish scale			
LOCALITY NO. 2.—LOWER MARTINEZ.			
1 *Flabellum Remondianum* Gabb		*	*
2 *Placosmilia* n. sp.....		*	
3 *Schizaster* (?) n. sp.....		*	
4 *Arca* n. sp.....		*	
5 *Cardium Cooperi* Gabb.....		*	†
6 *Cucullæa Mathewsoni* Gabb...		*	
7 *Leda Gabbi* Conr.....		*	*
8 *Lucina* sp.....		*	
9 *Meretrix* sp.....		*	
10 *Modiola* n. sp.....		*	
11 *Pholadomya nasuta* Gabb.....		*	
12 *Tapes quadrata* Gabb (*aff.*)...		*	*
13 *Tellina* n. sp.....		*	
14 *Actaeon* (?) n. sp.....		*	
15 *Cylichna costata* Gabb.....		†	*
16 *Dentalium Cooperi* Gabb	*	*	*
17 *Discohelix* n. sp.....		*	
18 *Fusus* n. sp. (*a*).....		*	
19 *Fusus* n. sp. (*b*).....		*	
20 Indet. nov.....		*	
21 *Neptunea mucronata* Gabb....		*	
22 *Perissolax Blakei* Conr. n. var.		*	
23 *Siphonalia lineata* Stanton....		*	
24 *Turritella* sp.....		*	
25 *Urosyca caudata* Gabb.....		*	
26 *Urosyca* n. sp.....		*	
27 *Xenophora* n. sp.....		*	
28 Glauconite.....			
29 Foraminifera.....			
LOCALITY NO. 3.—UPPER MARTINEZ.			
1 *Arca* n. sp.....		*	
2 *Cardium Cooperi* Gabb.....		*	†
3 *Cucullæa Mathewsoni* Gabb..		*	
4 *Leda Gabbi* Conr.....		*	
5 *Modiola ornata* Gabb.....		†	*
6 *Pholadomya nasuta* Gabb.....		*	
7 *Solen* n. sp.....		*	
8 *Tellina* (?) *undulifera* Gabb..		*	
9 *Brachysphingus liratus* Gabb.		*	
10 *Bullinula* (?) n. sp.....		*	
11 *Dentalium Cooperi* Gabb.....	*	*	
12 *Fusus* n. sp.....		*	
13 *Heteroterma Gabbi* Stanton ...		*	
14 *Perissolax Blakei* Conr. n. var.		*	
15 *Siphonalia lineata* Stanton....		*	
16 *Strepsidura pachecoensis*, Stanton.....		*	
17 *Turritella infragranulata* Gb.		*	
18 *Urosyca caudata* Gabb.....		*	
LOCALITY NO. 4.—NEAR UPPER LIMIT OF MARTINEZ.			
1 Nummuloid.....		*	
2 *Schizaster* (?) n. sp.....		*	
3 *Cardium Cooperi* Gabb.....		*	†
4 *Cardita Hornii* Gabb.....		†	*
5 *Modiola* n. sp.....		*	
6 *Solen* n. sp.....		*	
7 *Tellina Hornii* Gabb		†	*
8 *Tellina* n. sp.....		*	
9 *Thracia* (?) n. sp.....		*	
10 *Ampullina striata* Gabb (*conf.*)		*	
11 *Dentalium stramineum* Gabb..	*	*	*
12 *Ficopsis* sp. (near *Remondi*)..		*	*
13 *Megistostoma striata* Gabb....		†	*
14 *Morio* sp. (*tuberculatus?*).....		†	*
15 *Solarium* n. sp.....		*	
16 *Tritonium* n. sp		*	
17 *Tritonium* (?) n. sp		*	
18 *Turris* n. sp.....		*	
19 *Turritella* n. sp. (?).....		*	

[1] An asterisk indicates common or characteristic; a dagger, rare or characteristic of some other horizon.

TABLE.—*Continued.*[1]

	Chico	Martinez	Tejon
LOCALITY NO. 5.—TEJON, A SHORT DISTANCE ABOVE LOCALITY NO. 4.			
1 *Trochosmilia striata* Gabb....			*
2 *Cardium Breweri* Gabb.....			*
3 *Cardium Cooperi* Gabb		*	†
4 *Cardita Hornii* Gabb.....		†	*
5 *Meretrix Hornii* Gabb.....			*
6 *Meretrix uvasana* Conr.....			*
7 *Modiola ornata* Gabb.....		†	*
8 *Nucula truncata* Gabb.....	*	*	*
9 *Pectunculus sagittatus* Gabb..			*
10 *Amauropsis alveata* Gabb....			*
11 *Cylichna costata* Gabb.....		†	*
12 *Conus Remondi* Gabb.....			*
13 *Dentalium Cooperi* Gabb....	*	*	*
14 *Ficopsis Remondi* Gabb.....			*
15 *Ficopsis* sp. (near *Remondi*)...		*	*
16 *Morio* sp. (*tuberculatus*).....		†	*
17 *Perissolax Blakei* Conr. Typ. var.....			*
18 *Rimella canalifera* Gabb.....			*
19 *Turritella uvasana* Conr.....			*
20 *Oliverato californica* Cooper ..			*

the same type as that of No. 2 but containing some forms as *Tellina* (?) *undulifera*, *Turritella infragranulata*, and *Brachysphingus liratus*, not present in the lower beds. One minute specimen of the characteristic Tejon form, *Modiola ornata*, was obtained at this horizon.

At Locality No. 4, near the upper limit of the Martinez, about one third of the fauna is composed of species known from the Tejon. Of these forms *Dentalium stramineum* is a long-lived species ranging from Chico to Tejon. *Cardium Cooperi*, though known from Tejon beds, is not a common or characteristic fossil of that group, while it ranges through the Martinez and is one of its most characteristic species. The *Cardita* belongs to the Tejon species described as *Hornii* by Gabb but may be a new variety. *Megistostoma striata*, *Tellina Hornii* and the *Morio* seem to be typical Tejon forms and are not found below the uppermost beds of the Martinez. The *Ficopsis* sp. is a form known from the Upper Martinez and Lower Tejon. Imperfect specimens of a foraminifer related to *Nummulites* are abundant at this locality. Though the fauna at this horizon is certainly closely related to that of the true Tejon, only three good species are common or characteristic forms in that group.

[1] An asterisk indicates common or characteristic; a dagger, rare or characteristic of some other horizon.

At Locality 5, a short distance (less than 100 feet) above No. 4, fossils of the well-marked fauna to which Gabb gave the name Tejon are found in abundance, *Cardium Cooperi* being the only really characteristic Martinez species associated with them. No localities showing more gradation between the Martinez and Tejon faunas than those here discussed have so far been discovered by the writer.

Numerous other collections made between Localities 2 and 3 and between 3 and 4 furnished gradations from one to the other, with some additional species not mentioned in the foregoing lists.

In the following table there are placed together all of the species known to the writer from the strata between the Chico and the true Tejon near Martinez, along with those which have been collected elsewhere by Mr. Stanton, in beds of the same age. A study of this list shows clearly that the fauna is a unit, and that it is quite distinct from both the Chico and the Tejon, though it grades to some extent into the latter.

The existence between the Chico and the Tejon of a fauna not belonging clearly to either group, was evidently not unknown to Gabb, and this fauna formed the real basis of his Martinez. Unfortunately the involved stratigraphy led him or his collectors into the error of supposing that certain Chico forms belonged in the same horizon with Martinez species, while the first error led to a second, viz., the belief that, since Chico forms were present in his Martinez fauna, the whole group might be found later to represent a subdivision of the Chico. As has been shown in the comparison of faunas, there can be little doubt that the Chico group is widely separated from what is here called Martinez.

In considering the relations of the Martinez to the Tejon, it might be well to determine first what was intended in the original definition of the Tejon group and what it really is. The name was proposed by Gabb on *palæontological grounds* for a set of rocks, supposed by him to be Cretaceous, but now generally regarded as Eocene, "most extensively developed in the vicinity

THE FAUNA OF THE MARTINEZ GROUP WITH GEOLOGICAL RANGE OF THE SPECIES.[1]

	Chico	Martinez	Tejon
1 Foraminifera Nummuloid		*	
2 Foraminifera 3 sp. Indet.....			
3 *Flabellum Remondianum* Gabb.....		*	*
4 *Placosmilia* n. sp.....		*	
5 *Schizaster* (?) n. sp.....		*	
6 *Terebratula tejonensis* Stanton		*	
7 *Arca* n. sp.....		*	
8 *Cardita Hornii* Gabb.....		†	*
9 *Cardium Cooperi* Gabb.....		*	†
10 *Crassatella unioides* Stanton ..		*	
11 *Cucullæa Mathewsoni* Gabb...		*	
12 *Leda alæformis* Gabb.....		*	
13 *Leda Gabbi* Conr.....		*	*
14 *Lima multiradiata* Gabb.....		*	
15 *Lucina Turneri* Stanton.....		*	
16 *Meretrix* sp.....		*	
17 *Modiola* n. sp.....		*	
18 *Modiola ornata* Gabb.....		†	*
19 *Nucula truncata* Gabb.....	*	*	*
20 *Pectunculus Veatchi* var. *major* Stanton.....		*	
21 *Pholadomya nasuta* Gabb.....		*	
22 *Plicatula ostreiformis* Stanton		*	
23 *Solen* n. sp.....		*	
24 *Tapes quadrata* Gabb (*aff.*) ...		*	*
25 *Tellina* n. sp.....		*	
26 *Tellina Hornii* Gabb		*	*
27 *Tellina* (?) *undulifera* Gabb..		*	
28 *Teredo* (?).....			
29 *Thracia* (?) n. sp.....		*	
30 *Actaeon* (?) n. sp.....		*	
31 *Ampullina striata* Gabb (*conf.*)		*	
32 *Brachysphingus liratus* Gabb.		*	
33 *Bullinula* (?) n. sp.....		*	
34 *Cylichna costata* Gabb.....		†	*
35 *Dentalium Cooperi* Gabb.....	*	*	*
36 *Dentalium stramineum* Gabb	*	*	*
37 *Discohelix* n. sp.....		*	
38 *Ficopsis* sp (near *Remondi*)...		*	*
39 *Fusus* n. sp (*a*)		*	
40 *Fusus* n. sp. (*b*)		*	
41 *Heteroterma Gabbi* Stanton...		*	
42 *Heteroterma striata* Stanton..		*	
43 *Heteroterma trochoidea* Gabb.		(?)	
44 Indet. nov.....		*	
45 *Lunatia Hornii* Gabb.		†	*
46 *Megistostoma striata* Gabb...		†	*
47 *Morio* sp. *tuberculatus?*.....		†	*
48 *Natica* sp.....			
49 *Neptunea mucronta* Gabb....		*	
50 *Perissolax Blakei* Conr. nov. var.....		*	
51 *Siphonalia lineata* Stanton...		*	
52 *Solarium* n. sp		*	
53 *Stripsidura pachecoensis* Stanton.....		*	
54 *Tritonium* n. sp. (*a*)		*	
55 *Tritonium* (?) n. sp. (*b*).....		*	
56 *Turbinella crassitesta* Gabb ..		*	
57 *Turritella infragranulata* Gabb.....		*	
58 *Turritella pachecoensis* Stanton		*	
59 *Turritella* n. sp. (?).....			
60 *Turris* n. sp.....		*	
61 *Urosyca caudata* Gabb.....		*	
62 *Urosyca* n. sp		*	
63 *Xenophora* n. sp.....		*	
64 Crustacean remains, brachyuran.....		*	
65 Crustacean remains, macruran			
66 *Serpula*			

of Fort Tejon and about Martinez." It was stated[2] to contain "a large and highly characteristic series of fossils, the larger part peculiar to itself, while a considerable percentage is found

[1] An asterisk indicates common or characteristic; a dagger, rare or characteristic of some other horizon.

[2] Rep. Geol. Surv. Cal. Palæontology, Vol. II, p. 13 of Preface.

extending below into the next group, and several species still farther down into the Chico group." Since Gabb's work was published the Tejon has been recognized at numerous points on the Pacific coast, outside the limits of its distribution as known to him, and has always been found to contain an easily recognized fauna, of which a number of the most common and characteristic forms are found in the list of species from locality No. 5. As may be seen in the last quotation, the true relation of the Martinez to the Tejon, as shown by the partial mingling of species, was not unknown to Gabb.

In the vicinity of the town of Martinez, the Martinez and Tejon groups form an apparently conformable series between two and three thousand feet in thickness and about equally divided between the two. The faunas, though overlapping, are in the main quite distinct and no great difficulty has been experienced by the writer in separating the groups on this basis. While some intermingling of species exists, it is not greater than we should expect to find in adjoining groups or periods. It should also be observed that the beds with a Tejon-like Martinez fauna and those containing an assemblage of characteristic Tejon forms are comparatively close together. The change from one fauna to the other may possibly have taken place in a short time by migration, but we cannot assert positively as yet that the apparent conformity of the beds is a real one, sedimentation may have been interrupted between the times of deposition of the two groups. It is at any rate quite clear that the two sets of strata, or two faunas, while belonging perhaps to the same series, represent different periods in the geological history of California, periods quite as distinct, so far as faunal evidence is concerned, as the Miocene and Pliocene, or the Pliocene and Quaternary. The upper division of this series has already, on the grounds of its characteristic fauna, been named the Tejon. To a mixed group of rocks, to which the fauna here called the Martinez gave individuality, the name Martinez group was applied by Gabb. It seems desirable, after having cut out the Chico portion of Gabb's Martinez which was probably not the one on which he based the group,

to apply the name used by him to the distinct fauna or group which remains. As to the nomenclature of the supposedly conformable series, including the Martinez and Tejon, it seems best to apply to it for the present the term Martinez-Tejon series, though future convenience may demand a special series name. To apply the name Tejon to the whole series would be to modify considerably the meaning of this term as used originally, and would have besides the fault of taking the name from a smaller division to apply it to a larger, leaving the first to be virtually renamed.

In conclusion, the group under consideration might be characterized as follows: The Martinez group, comprising in the typical locality between one and two thousand feet of sandstones, shales, and glauconitic sands, forms the lower part of a presumably conformable series, the upper portion of which is formed by the Tejon. It contains a known fauna of over sixty species, of which the greater portion is peculiar to itself. A number of its species range up into the Tejon and a very few long-lived forms are known to occur also in the Chico. Since the Martinez and Chico are faunally only distantly related it is probable that an unconformity exists between them. Though satisfactory correlation of Californian formations with the subdivisions of the standard geological scale can be accomplished only when the local scale is fully worked out, we may, for the present at least, accept Mr. Stanton's correlation of the Martinez with a portion of the Eocene.

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